PHASE II General Notes

R. A. Gibbons

1. Some Background

The upcoming HST Spring 2004 search is now expected to begin in April. Originally, this search was proposed to be part of a Treasury program submitted by S. Faber. Faber invited both the SCP and High-Z groups to help design a survey which would also accomodate a rolling SN Ia search. In the end, the HST TAC accepted the SCP and High-Z programs, despite not taking on the Faber program. It was put to the supernova groups that we would instead search off an ACS survey program (GO-9822) led by N. Scoville. However, the logistics could not be worked out to the satisfaction of all parties involved; we (SCP and High-Z) therefore were each given 25 orbits from GO-9822 with which to operate a separate and dedicated rolling supernova search.

This search will run somewhat like the Optical Transient Search portion of the **GOODS** HST/ACS Treasury Program which ran from July 2002 through May 2003. The **GOODS** ACS program (GO-9425, 9583) design included deep, multi-color imaging of areas of sky surrounding the HDF-N and CDF-S. In each field, depth was built up at $15-16$ pointings in perpendicular telescope orientations over 5 observing epochs separated by 45 days in order to also search for time-variable and transient objects, such as SNe, in addition to the many other science goals. This resulted in 8 search epochs, 4 on the HDF-N field and 4 on the CDF-S field. Time (134 HST orbits) to follow-up approximately 6 SN Ia candidates was granted to Riess et al. (GO-9352).

For the current program, the SCP and High-Z groups will coordinate and conduct 4 searches of the HDF-N fields using the ACS/WFC. Our programs fall under GO-9727 (SCP – PI Perlmutter) and GO-9728 (High-Z – PI Riess). After some iteration, we finally may have a workable search timetable. We think the search dates will be something like :

Search 1 : $02-04$ Apr

Search 2 : $21-23$ May $\sim$ 7 week interval

Search 3 : $07-08$ Jul $\sim$ 7 week interval

Search 4 : $25-26$ Aug $\sim$ 7 week interval.

Searches 1 and 3 will be scheduled under GO-9727, and searches 2 and 4 under GO-9728. First right of refusal on SNe will alternate between teams starting with the SCP for search 1, for which we don't expect to have 6-7 week old reference imaging from the ground. We will therefore search off the original **GOODS** data. Each search will cover 15 **GOODS** pointings with $\sim$ 1600 s in *z*-band (ACS/WFC/F850LP) and 400 s in *i*-band (ACS/F775W). We expect to be able to detect objects fainter than 26 AB mags in the *z*-band subtractions. For reference, a z$\sim$ 1.5 SN Ia found as early as -7 days before or as late as $+5$ days after max (restframe) should have $z_{\rm AB} \sim 25.3 \pm 0.4$ (N.b. subtract 0.55 to go from AB to Vega). The 50 orbits taken from GO-9822 will cover the first 3 searches. Another 10 orbits from DD time, makes 60 orbits which with to conduct 4 search runs (15 orbits per search). The fourth search will only be conducted if the first three do not produce enough SNe to fill our follow-up time (see below). Both groups have 60 orbits follow-up time under GO-9727 and GO-9728. Our Program Coordinator (PC) is William Januszewski at STScI Our instrument Contact Scientists (CS) are Ron Gilliland for the ACS and Tommy Wiklind for NICMOS.

2. A Few Remarks Regarding the STScI Proposal Software

Formerly, the Phase II observing instructions were prepared and submitted to STScI using the RPS2 software. HST schedulers now want observers to submit Phase II files using the java-based APT (Astro Proposal Tool) which was also used for the last round of Phase I proposals. The APT file which is sent to STScI is XML, but one can also output to a more easily readable text version.

Some instrument configurations cannot be implemented by observers without prior approval. One such example is switching off the direct image in F606W prior to each ACS grism exposure. A direct image is needed to calculate the position of the dispersed spectrum on the detector, but we would obviously rather use an F850LP image which will serve a dual purpose as light-curve data. One needs to change the availability keyword from “SUPPORTED” to “AVAILABLE” which frees up loads of options including this one. Any special configurations done in “AVAILABLE” mode must be approved by the CS before such observations will be implemented. Ron Gilliland has reviewed and approved our use of this mode 07 Jan 04.

For anyone interested, the current search and follow-up observations can be found on the collab HST search page and I’ve also linked them from here : 9727.prop (ascii) or 9727.prop.ps (postscript) .
Although the search dates haven’t been finalized, hopefully further modification won’t be necessary. The target positions and telescope orientation were taken directly from the **GOODS** info. Exposure times are approximate based on “average” HST visibilities. Scheduling will fill up orbits for us. For some idea of what exposure times per orbit are expected over the entire observing period, see : 9728visibilityBEA25.txt , also on the HST search page (this came from our Program Coordinator).

3. Basic Search Strategy

Table 1 summarizes the search observations contained in 9727.prop. The layout of the observations follow the **GOODS** configuration (see Figure 1).

4. Basic Follow-up Strategy

I built the current follow-up plan based on 9 scenarios.

– The 1st set (A, B, C) represents the nominal case for which we find a grism spectrum is not necessary, because we have a good photometric redshift and morphology for the host galaxy from the **GOODS** reference data.

– The 2nd set (D, E, F) adds grism observations near maximum light.

– The 3rd set (G, H, I) adds more color data in lieu of spectra if we decide we have a suitable C-Magic candidate.

• ACS/WFC *z*-band observations will be taken in a 4-point per orbit box dither pattern combining approximately whole and sub-pixel shifts of $0\farcs265$.

• NICMOS/NIC2 observations will be taken in a 2-point per orbit line or box dither pattern with $1\farcs5$ shifts and "SPARS64" sampling.

• ACS/WFC grism observations will be taken in a series of shifted 2-point per orbit box patterns like the imaging observations in that they include whole and sub-pixel shifts. Acceptable "ORIENT" to minimize interference from nearby bright sources plus "POS-TARG" to avoid the inter-chip boundary will be determined at search-time, keeping in mind the linear size of the 1st order spectrum in the dispersion dimension is ~ 150 pixels ($\sim 7''$) and the 1st order is separated from the 0th order by ~ 125 pixels ($\sim 6''$). The extent of all orders $\sim$ 1200 pixels ($\sim$ $60''$), will also be taken into account when there are bright neighboring sources. The companion ACS *z*-band direct image will be taken at the same "ORIENT" as the grism observations. For future reference, information on HST projected roll angle restrictions for the entire search and follow-up period can be found on the collab HST search page and is linked to here : rollangle.txt

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Tables 2, 3, & 4 briefly outline the follow-up observations contained in the Phase II program, i.e., the ACS/WFC/F850LP search orbits are not included in this table.

5. Built-in Considerations

POINTINGS

If the search dates remain as expected, the 1st and 3rd searches will be on 15 **GOODS** HDF-N "tilted" pointings (fields $21 - 35$).

FILTERS

Search :

ACS/WFC/F850LP (4×400 s) + ACS/WFC/F775W (1×400 s)

Follow-up :

ACS/F850LP (*z*), ACS/G800L (grism spectroscopy), NIC2/F110W (J), NIC2/F160W (H)

DITHERING

All *z*-band observations (including the search) are done in a 4-point per orbit pattern. NICMOS observations are 2-point per orbit dithers. Grism observations will also be dithered.

CR-SPLITS

N/A : multiple dither points serve this purpose for the ACS observations, and multiple reads allow good cosmic ray rejection for the NICMOS observations.

EXPOSURE TIMES

I estimated exposure times using Rob's uberspectrum to build model lightcurves. Using SNMinuit, I determined what SNR goals to set for lightcurve points in order to get decent stretch and color measurements. I may get around to writing up the details of these many triels, but i have discussed a lot of this during telecons.

NUMBER AND TIMING OF EPOCHS

This is based on a few reasonable lightcurve sampling schemes and our orbit allocation. The nominal case consists of 4 *z*-band lightcurve points (in addition to the discovery point), 3 J-band points, 1 H-band point. The IR observations are staggered in time with respect to the *z*-band points in order to help break degeneracies which occur when fitting the lightcurves. The follow-up observations cover about 40 days in the observer frame and extend into subsequent search periods by a few days. Any grism observations will be taken immediately with the 1st *z*-band follow-up point. In the observing specs, the date of the first visit in each series will be determined when we activate a ToO and will be scheduled as soon after discovery as possible. For subsequent observations, visits are timed in days with respect to the first. Final reference images are also included for the IR observations only because the **GOODS** data provide reference data for the ACS imaging (Thanks Gerson for reminding everyone of this).

6. Other Notes

Q. Proprietary period for our follow-up data?

A. Needs confirmation. We originally thought as part of a Treasury scheme, our follow-up data would be non-proprietary, but with the many changes in program which have occured, it's no longer clear we will be forced to make the data immediately public (especially since the GO-9728 program was granted the standard proprietary period of a year).

Q. Visit timing is w.r.t. the first follow-up visit. If the first follow-up observation does not occur when scheduled, will the rest in the sequence go as scheduled, or by when the first actually is taken?

A. Need to ask our PC. But one way to avoid this problem would be to hardwire in each epoch date separately when an SN candidate is submitted for follow-up.

Follow-up. Bill Januszewski says that when the times comes it will be most robust to fix the timing using "BETWEEN"s instead of "AFTER"s, because the timing may get pushed back if the 1st epoch doesn't execute on time.

Q. Color accuracy vs. stretch accuracy. Is it better to stagger the IR data among the *z*band points?

A. Given we are pushing the limit of accurately determining stretch with the staggered *z* + IR lightcurves, we should stick with this strategy, and as Rob points out, it'll be necessary to get reliable lightcurve fits. This shouldn't lessen our ability to get good color measurements. Afterall, the offset between the *z*band and IR points amounts to only about 2 rest frame days. Therefore, interpolating to get colors shouldn't be horrible.

Q. Frequency and duration of SAA affected orbits.

A. Vitaliy says twice per day, so can find times each day which are not affected by SAA passages. As a reminder to the schedulers, I wrote into the timing requirements that NICMOS observations must avoid the SAA.

Q. LOW-SKY v. AVG-SKY

A. In terms of SNR, the extra exposure time gained in AVG-SKY mode wins over LOW-SKY for our 1-3 orbit exposure times. Although, ACS observations of sources at the lowest flux levels we expect are becoming background-limited. Still, the SNR reached for LOW-SKY observations is lower than in AVG-

SKY mode. In the end I didn't require LOW-SKY observations anywhere in the program.

Q. Good NICMOS apertures

A. The NICMOS observations will be done with only two pointings per orbit (longer exposures in order to cut down on the significance of read noise), Vitaliy was to supply me with two good sections of the NIC2. These will be specified in the PHASE II as POS TARGS. We really should check for recent updates of bad pixel maps.

Q. As per Greg's suggestion, I included in the follow-up program a series of observations for a lower redshift case in the event we are unlucky. These observations would be taken in *i*, *z*, and J.

Q. N.b., coverage of the **GOODS** field in the "tilted" orientation required 16, not 15 pointings. **A.** I think it will be best and simplest solution is to drop the last tile in the sequence, "HDF-NORTH-GOODS-TILE-TILT-16" (number 36 in Figure 1). But we should confirm Adam's assent.

Table 1. Search Summary

Search	GO-	Dates	Fields	Orients	ACS/F850LP	Comments	ACS/F775W	Comments
1	9727	02-04/04/04	HDF-NORTH-GOODS-TILE-TILT-1-15	180	4 x 400s	4 dither points, WFCENTER, GAIN=1	1 x 400s	no dithering, no CR-SPLIT, WFCENTER, GAIN=1
2	9728	21-23/05/04	HDF-NORTH-GOODS-TILE-NORM-1-15	135	4 x 400s	4 dither points, WFCENTER, GAIN=1	1 x 400s	no dithering, no CR-SPLIT, WFCENTER, GAIN=1
3	9727	07-08/07/04	HDF-NORTH-GOODS-TILE-TILT-1-15	90	4 x 400s	4 dither points, WFCENTER, GAIN=1	1 x 400s	no dithering, no CR-SPLIT, WFCENTER, GAIN=1
4	9728	25-26/08/04	HDF-NORTH-GOODS-TILE-NORM-1-15	45	4 x 400s	4 dither points, WFCENTER, GAIN=1	1 x 400s	no dithering, no CR-SPLIT, WFCENTER, GAIN=1

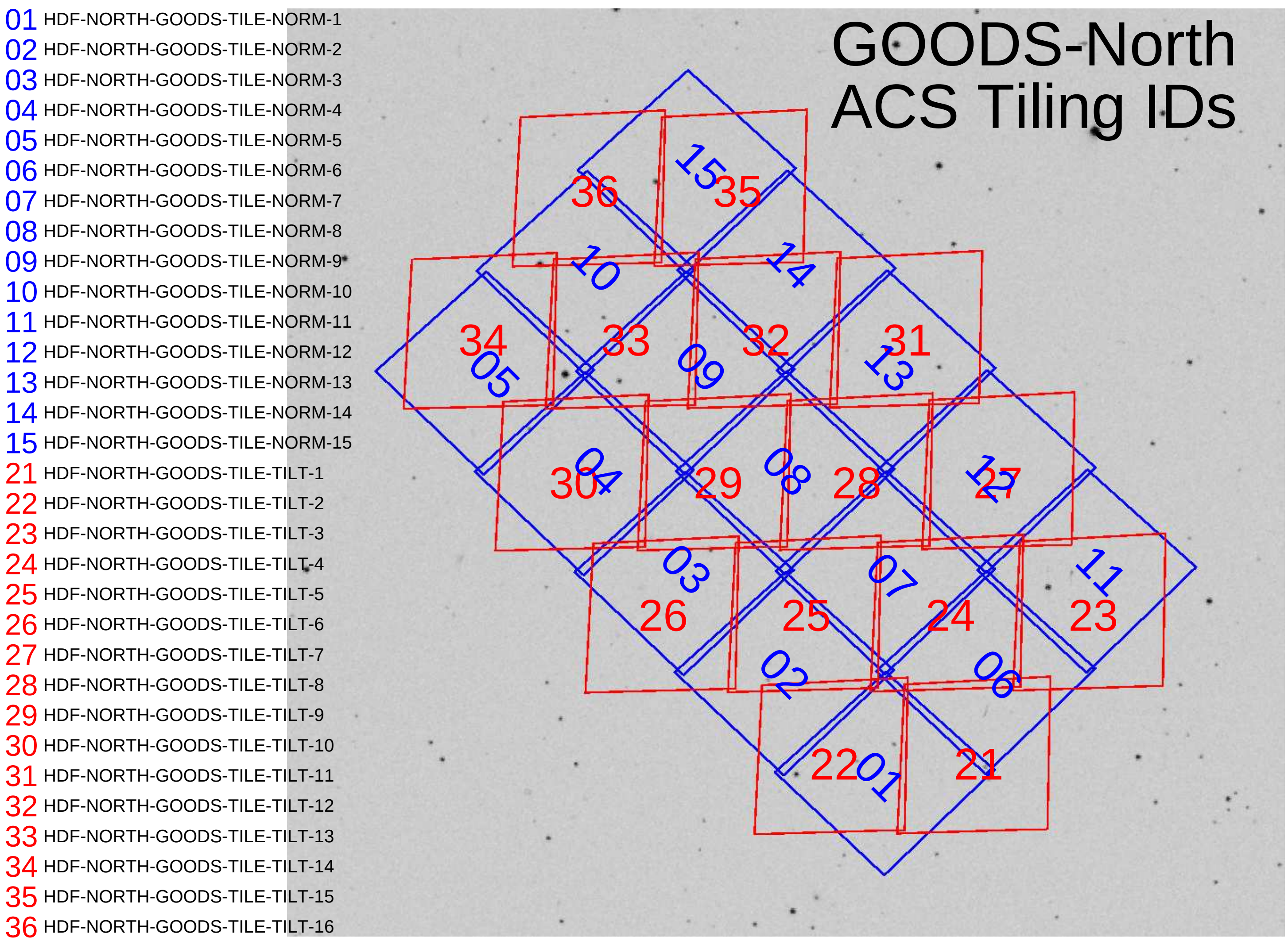

Fig. 1.— Figure of **GOODS**-North layout from **GOODS** web pages.

Table 2. FOLLOW-UP ORBIT SUMMARY

Case	*z*-band Orbits	Grism Orbits	J-band Orbits	H-band Orbits	Total Orbits	Comments
A	5 (4 epochs)	-	4 (3 epochs)	4 (1 epoch)	13	z=1.20, no spectroscopy
B	7 (4 epochs)	-	4 (3 epochs)	4 (1 epoch)	15	z=1.35, no spectroscopy
C	9 (4 epochs)	-	4 (3 epochs)	4 (1 epoch)	17	z=1.50, no spectroscopy
D	5 (4 epochs)	7 (1 epoch)	4 (3 epochs)	4 (1 epoch)	20	z=1.20, same as A + grism
E	7 (4 epochs)	9 (1 epoch)	4 (3 epochs)	4 (1 epoch)	24	z=1.35, same as B + grism
F	9 (4 epochs)	11 (1 epoch)	4 (3 epochs)	4 (1 epoch)	28	z=1.50, same as C + grism
G	5 (4 epochs)	-	5 (4 epochs)	8 (3 epochs)	18	z=1.20, same as A + more IR
H	7 (4 epochs)	-	5 (4 epochs)	8 (3 epochs)	20	z=1.35, same as B + more IR
I	9 (4 epochs)	-	5 (4 epochs)	8 (3 epochs)	22	z=1.50, same as C + more IR

Table 3. FOLLOW-UP EPOCH SUMMARY

	Number of Orbits	Number of Orbits	Number of Visits
ACS Visits			
Epoch 1	1-2 ACS/F850LP	7-11 ACS/G800L †	2-3
Epoch 2	1-2 ACS/F850LP		1
Epoch 3	1-2 ACS/F850LP		1
Epoch 4	1-2 ACS/F850LP		1
NIC Visits			
Epoch 1a	1 NIC2/F110W	2 NIC2/F160W	1
Epoch 2a	1 NIC2/F110W	2 NIC2/F160W †	1
Epoch 3a	1 NIC2/F110W	2 NIC2/F160W †	1
Epoch 4a	1 NIC2/F110W †		1
Final Refs			
	1 NIC2/F110W	2 NIC2/F160W	1 (1 year later)

† These options may not be necessary.

Table 4. More Follow-up Details

		ACS/F775W		ACS/F850LP		NIC/F110W		NIC/F160W		ACS/G800L		
Scenario	z	Follow-up Day [a]	HST Orbits	Follow-up Day [a]	HST Orbits	Follow-up Day [a]	HST Orbits	Follow-up Day [a]	HST Orbits	Follow-up Day [a]	HST Orbits	Total [b] Orbits
A , D	1.20	–	–	0	1	5-6	1	5-6	2	0	7	13 , 20
		–	–	11-12	1	29-30	1	–	–	–	–	
		–	–	23-24	1	41-42	1	–	–	–	–	
		–	–	35-36	2	1 yr	1	1 yr	2	–	–	
B , E	1.35	–	–	0	1	5-6	1	5-6	2	0	9	15 , 24
		–	–	11-12	1	29-30	1	–	–	–	–	
		–	–	23-24	2	41-42	1	–	–	–	–	
		–	–	35-36	3	1 yr	1	1 yr	2	–	–	
C , F	1.50	–	–	0	2	5-6	1	5-6	2	0	11	17 , 28
		–	–	11-12	2	29-30	1	–	–	–	–	
		–	–	23-24	2	41-42	1	–	–	–	–	
		–	–	35-36	3	1 yr	1	1 yr	2	–	–	
G	1.20 †	–	–	0	1	5-6	1	5-6	2	–	–	18
		–	–	11-12	1	17-18	1	–	–	–	–	
		–	–	23-24	1	23-24	1	23-24	2	–	–	
		–	–	35-36	2	35-36	1	35-36	2	–	–	
		–	–	–	–	1 yr	1	1 yr	2	–	–	
H	1.35 †	–	–	0	1	5-6	1	5-6	2	–	–	20
		–	–	11-12	1	17-18	1	–	–	–	–	
		–	–	23-24	2	23-24	1	23-24	2	–	–	
		–	–	35-36	3	35-36	1	35-36	2	–	–	
		–	–	–	–	1 yr	1	1 yr	2	–	–	
I	1.50 †	–	–	0	2	5-6	1	5-6	2	–	–	22
		–	–	11-12	2	17-18	1	–	–	–	–	
		–	–	23-24	2	23-24	1	23-24	2	–	–	
		–	–	35-36	3	35-36	1	35-36	2	–	–	
		–	–	–	–	1 yr	1	1 yr	2	–	–	
J	0.90 ††	0	1/2	0	1/2	5-6	1	–	–	0	5	8 , 13
		12-13	1/2	12-13	1/2	18-19	1	–	–	–	–	
		24-25	1/2	24-25	1/2	30-31	1	–	–	–	–	
		35-36	1/2	35-36	1/2	1 yr	1	–	–	–	–	

[a]This is observed days with respect to the 1st follow-up observation.

[b]When applicable, the 2nd number is the total including grism orbits.

† In these cases, the last two IR observing epochs roughly coincide with *z*-band for more accurate color in the C-Magic linear region. First J-band and H-band points remain offset.

†† This is for one low-redshift candidate. Unfortunately we can not go less than an orbit in the IR because we have to work in integers – but if we have 2 low-redshift candidates with are near each other on the sky so that the telescope doesn't have to do a large slew, it my be acceptable to split the IR orbits in half, hoping we don't get a CR hit on source. In this case we would get imaging on 2 SNe with 12 orbits.